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Alternative Artificial Vein Graft Biomaterials

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Alternative Artificial Vein Graft Biomaterials

Alexander J. Whitehead

Abstract

Current artificial vein grafts for long-term dialysis and bypass surgeries suffer from atherosclerosis and restenosis, and they tend to thrombose after initial patient recovery. The alternative materials, coatings, and polymer interfaces being explored in stents may be useful in graft applications, increasing both the quantity and quality of the patient's life. To better comprehend the clinical standards and developing alternatives, I collected previously identified physical and chemical venous properties, as well as the corresponding synthetic materials that would support them. I compiled studies of primary and secondary endpoints (such as death, myocardial infarction, thrombosis, and target-lesion revascularization) in various graft materials, polymer coatings, and drugs to gauge efficacy. Based on my findings, I suggest that everolimus coatings linked to polytetrafluoroethylene (PTFE) grafts by poly(n-butyl methacrylate) (PBM) should be subjected to further clinical research and *in-vivo* trials.

Introduction

Modern artificial graft options evolved over time from much simpler designs. The first attempts at artificial vein grafts began in the 1930s with Dupont, who created a thin-walled, carbon coated and pre-cuffed graft made out of polytetrafluoroethylene (PTFE)^[1]. It was made in a ringed configuration with a porous structure. It essentially looked like a small plastic tube. In 1950, DuPont manufactured a polyethylene terephthalate vascular implant that had to be pre-clotted. The fabric was woven, and it used collagen or albumin, which are used today. Gortex was also developed, which contained heparin that lasted for more than 230 days in vivo. Later, in 2004, this was proven by Dr. P. Lin in the *Journal of Vascular Surgery* to reduce neointimal hyperplasia. Most recently, polyurethane grafts have been proven to be more effective than the alternative materials, though they may be carcinogenic.

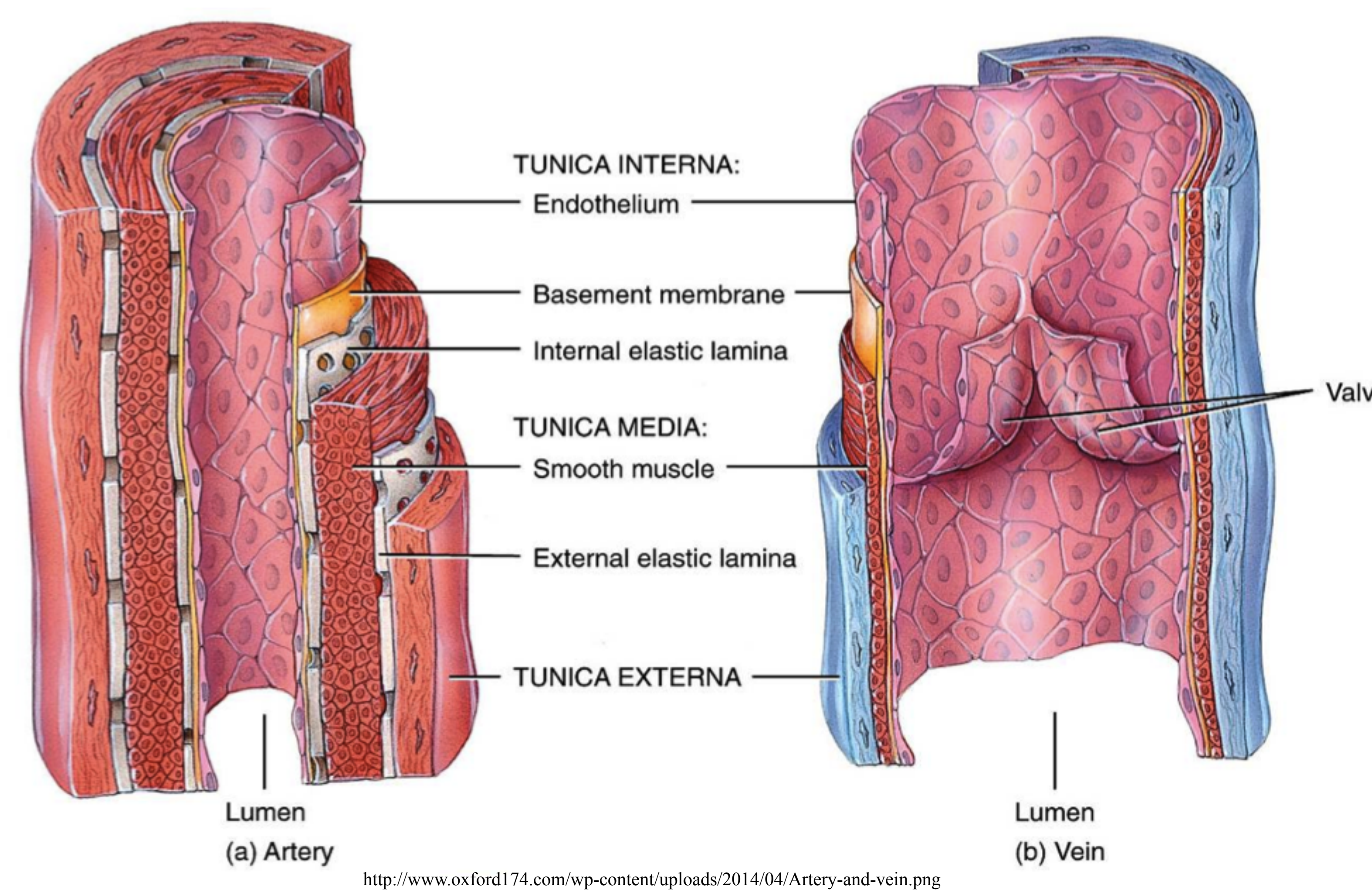
In 1995, about 50% of vein grafts failed within 10 years due to neointimal hyperplasia, or the closing of the vein from the inside by the buildup of plaque, cholesterol, and other particles found in the blood^[1]. When this happens, smooth muscle cells (SMC) line the inside of the graft in response to stress from the surgery or shear stress from blood flow. These cells quickly buildup and are extremely prone to atherosclerosis. When this happens, a temporary fix is balloon angioplasty, in which a catheter is inserted to the site of

of blockage, and then a balloon expands to widen the vein and push the plaque to the outside of the vein. A filter basket is placed downstream from the balloon to catch any debris that may have been knocked loose. In cases of more severe atherosclerosis, however, this is not possible.

Ideally, engineered endothelial cells could be added to the graft, but that would require overcoming several technological and biological barriers: finding the problem genes, inserting the replacement genes into the endothelial cells without stimulating an immune response, culturing those cells, and attaching the cells to the grafts. Instead, engineering the exterior and then adding a coating would be much easier. According to the Duke Department of Vascular Surgery, the ideal graft would allow a flow rate of 500 mL/min, resist infection, not cause an immune system response, and be inserted easily. Furthermore, the graft access should not have weeping, be easily clipped, resist infection, and be revised if need be ^[2].

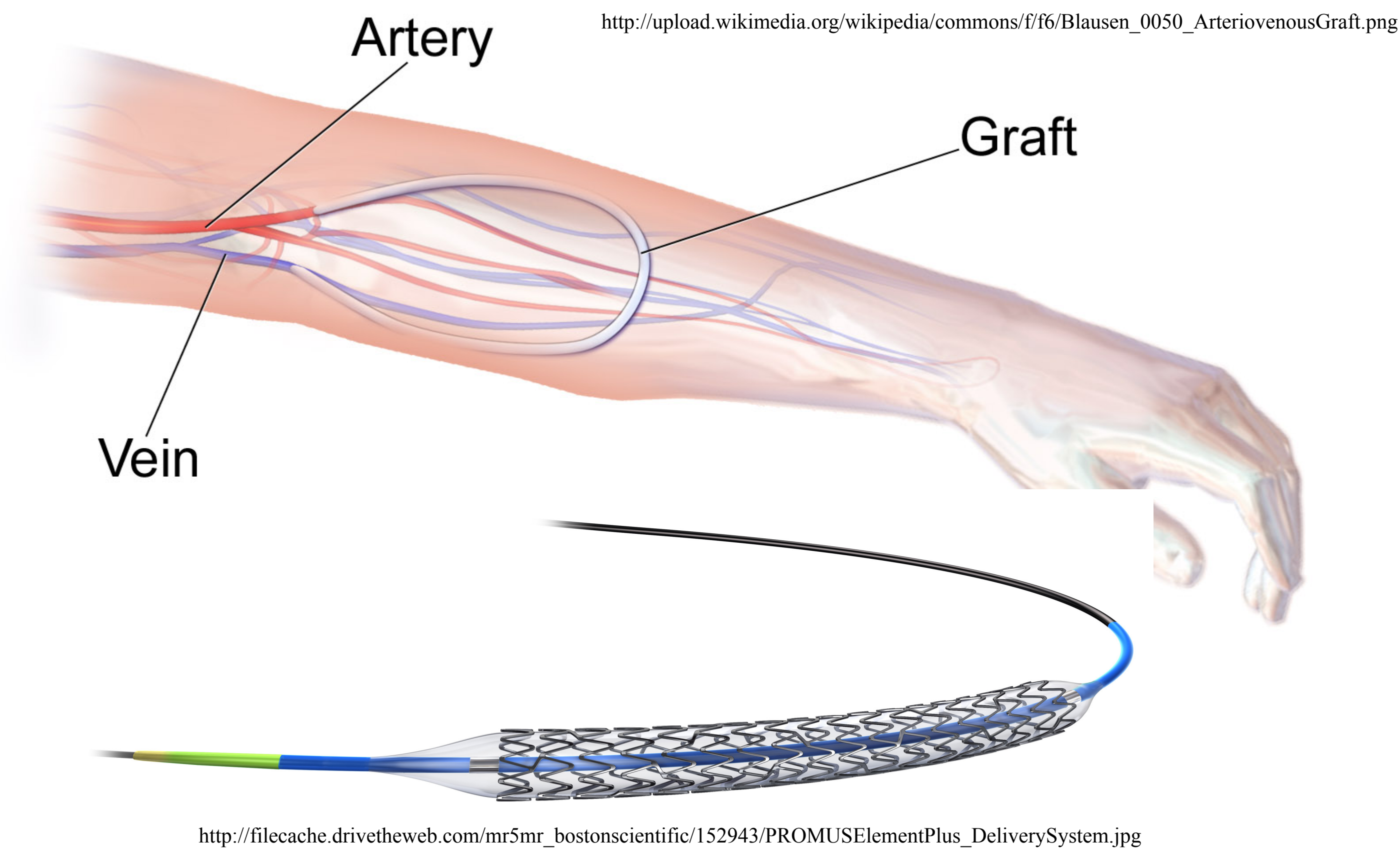
Materials/Methods

To better comprehend the clinical standards and developing alternatives, I collected previously identified physical and chemical venous properties, as well as the corresponding synthetic materials that would support them. I compiled studies of primary and secondary endpoints (such as death, myocardial infarction, thrombosis, and target-lesion revascularization) in various graft materials, polymer coatings, and drugs to gauge efficacy.



Results

In comparisons between various vein graft exteriors, polymers, and drugs, polytetrafluoroethylene (PTFE) grafts lasted the longest, everolimus was the drug that decreased primary endpoint failure the most, and poly(n-butyl methacrylate) (PBMA) acted as the most efficient interface. The only caveats in this combination is that PTFE is still being investigated as a carcinogen, and that everolimus may increase the risk of myocardial infarction, or heart attack. The next best alternative is sirolimus, which has been widely used since the early 2000s and is anchored by poly(n-butyl methacrylate) (PBMA) and poly(ethylene-co-vinyl acetate) (PEVA).



Discussion/Conclusion

Based on my research so far, the tentative answer to my research question is that everolimus coatings linked to polytetrafluoroethylene (PTFE) grafts by poly(n-butyl methacrylate) (PBMA) should be subjected to further clinical research and *in-vivo* trials. I think the authors who advocate for PTFE grafts have stronger studies with more conclusive evidence, especially compared to those who like resorbable models. The main point of contention exists in the type of drug that could be added to make a composite graft, as well as the nature of the polymer that would anchor it. I think most scientists realize that the future of grafts lies in bio-absorbable polymers, but more improvements need to be made in the mean time since current models are not completely safe and elude too quickly. As of right now, cobalt and chromium PTFE grafts are the most successful in people without risk of heart attack, everolimus is the best drug, and PBMA is the most effective polymer.

References

1. Vascular Grafts [Slideshow]. Duke Vascular Surgery, a Division of the Department of Surgery. Color Slideshow.
2. Mann MJ, Gibbons GH, Kernoff RS, Diet FP, Tsa PS, Cooke JP, Kaneda Y, Dau VJ. Genetic engineering of vein grafts resistant to atherosclerosis. Proceeding of the National Academy Sciences USA May 1995;92:4502-4506.
3. Decorato I, Kharboutly Z, Vassallo T, Penrose J, Legallais C, Salsac A. Numerical simulation of the fluid structure interactions in a compliant patient-specific arteriovenous fistula. International Journal for Numerical Methods in Biomedical Engineering 2013 Nov 5;30:143-159.
4. Bastounis E, Georgopoulos S, Maltezos C, Alexiou D, Chiotopoulos, Bramis J. PTFE-vein Composite Grafts for Critical Limb Ischaemia: a Valuable Alternative to AII-autogenous Infrageniculate Reconstructions. European
5. Simsek C, Raebler L, Magro M, Boersma E, Onuma Y, Stefanini GG, Zanchin T, Kalesan B, Wenaweser P, Jueni P, and others. Long-term outcome of the unrestricted use of everolimus-eluting stents compared to sirolimus-eluting stents and paclitaxel-eluting stents in diabetic patients: The Bern-Rotterdam diabetes cohort study. International Journal of Cardiology 2013 Oct 12;170:36-42.6. Roy-Chaudhury P, El-Khatib M, Campos-Naciff B, Wadehra D, Ramani K, Leesar M, Mistry M, Wang, Y, Chan J, Lee T, and others. Back to the Future: How Biology and Technology Could Change the Role of PTFE Grafts in Vascular Access Management. Seminars in Dialysis 2012 Sep;25(5): 495-504.
7. Parker T, Davé V, Falotico R. Polymers for Drug Eluting Stents. Current Pharmaceutical Design 2010; (16): 3978-3988.
8. Bangalore S, Toklu B, Amoroso N, Fusaro M, Kumar S, Hannan E, Faxon D, Feit F. Bare metal stents, durable polymer drug eluting stents, and biodegradable polymer drug eluting stents for coronary artery disease: mixed treatment comparison meta-analysis. British Medical Journal 2013 Nov 8;347:f6625.